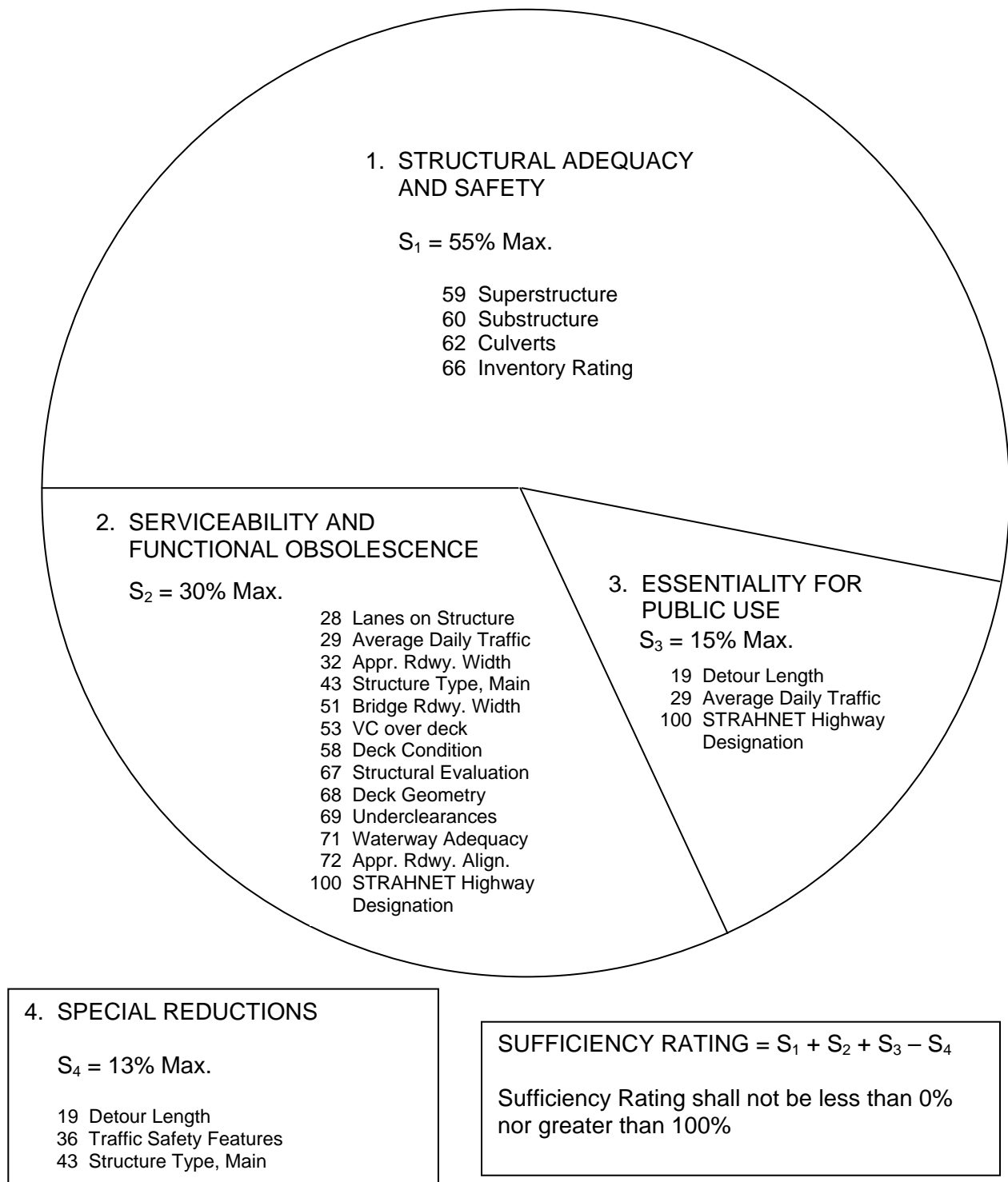# SUFFICIENCY RATING CALCULATION

Sufficiency Rating Formula and Example

The sufficiency rating formula described herein is a method of evaluating highway bridge data by calculating four separate factors to obtain a numeric value which is indicative of bridge sufficiency to remain in service. The result of this method is a percentage in which 100 percent would represent an entirely sufficient bridge and zero percent would represent an entirely insufficient or deficient bridge.

An asterisk prefix is used to identify a sufficiency rating that was calculated even though some essential data was missing or coded incorrectly. The Edit/Update Program will substitute a value for the unusable data (which will not lower the rating) and calculate the sufficiency rating. The asterisk is dropped when the unusable data is corrected. It is normal that all culverts with Bridge Roadway Width, Curb-to-Curb – Item 51 coded '0000' will have an asterisk prefixed sufficiency.

Figure 1. Summary of Sufficiency Rating Factors

1. STRUCTURAL ADEQUACY
   AND SAFETY

   S_1 = 55% Max.

   - 59 Superstructure
   - 60 Substructure
   - 62 Culverts
   - 66 Inventory Rating

2. SERVICEABILITY AND
   FUNCTIONAL OBSOLESCENCE

   S_2 = 30% Max.

   - 28 Lanes on Structure
   - 29 Average Daily Traffic
   - 32 Appr. Rdwy. Width
   - 43 Structure Type, Main
   - 51 Bridge Rdwy. Width
   - 53 VC over deck
   - 58 Deck Condition
   - 67 Structural Evaluation
   - 68 Deck Geometry
   - 69 Underclearances
   - 71 Waterway Adequacy
   - 72 Appr. Rdwy. Align.
   - 100 STRAHNET Highway Designation

3. ESSENTIALITY FOR
   PUBLIC USE

   S_3 = 15% Max.

   - 19 Detour Length
   - 29 Average Daily Traffic
   - 100 STRAHNET Highway Designation

4. SPECIAL REDUCTIONS

   S_4 = 13% Max.

   - 19 Detour Length
   - 36 Traffic Safety Features
   - 43 Structure Type, Main

SUFFICIENCY RATING = $S_1 + S_2 + S_3 - S_4$

Sufficiency Rating shall not be less than 0% nor greater than 100%

Sufficiency Rating Formula

1.   Structural Adequacy and Safety (55% maximum)

    a.   Only the lowest code of Item 59, 60, or 62 applies.

       If #59 (Superstructure Rating) or

#60 (Substructure Rating) is		then	
	≤ 2	then	A = 55%
	= 3		B = 40%
	= 4		C = 25%
	= 5		D = 10%

       If #59 and #60 = N and

#62 (Culvert Rating) is		then	
	≤ 2	then	E = 55%
	= 3		F = 40%
	= 4		G = 25%
	= 5		H = 10%

    b.   Reduction for Load Capacity:

       Calculate using the following formulas where IR is the Inventory Rating in tons or use Figure 2:

$$I = (36 - IR)^{1.5} \text{ x } 0.2778$$

       If $(36 - IR) \leq 0$, then B = 0

       "B" shall not be less than 0% nor greater than 55%.

$$S_1 = 55 - (A + B + C + D + E + F + G + H + I)$$

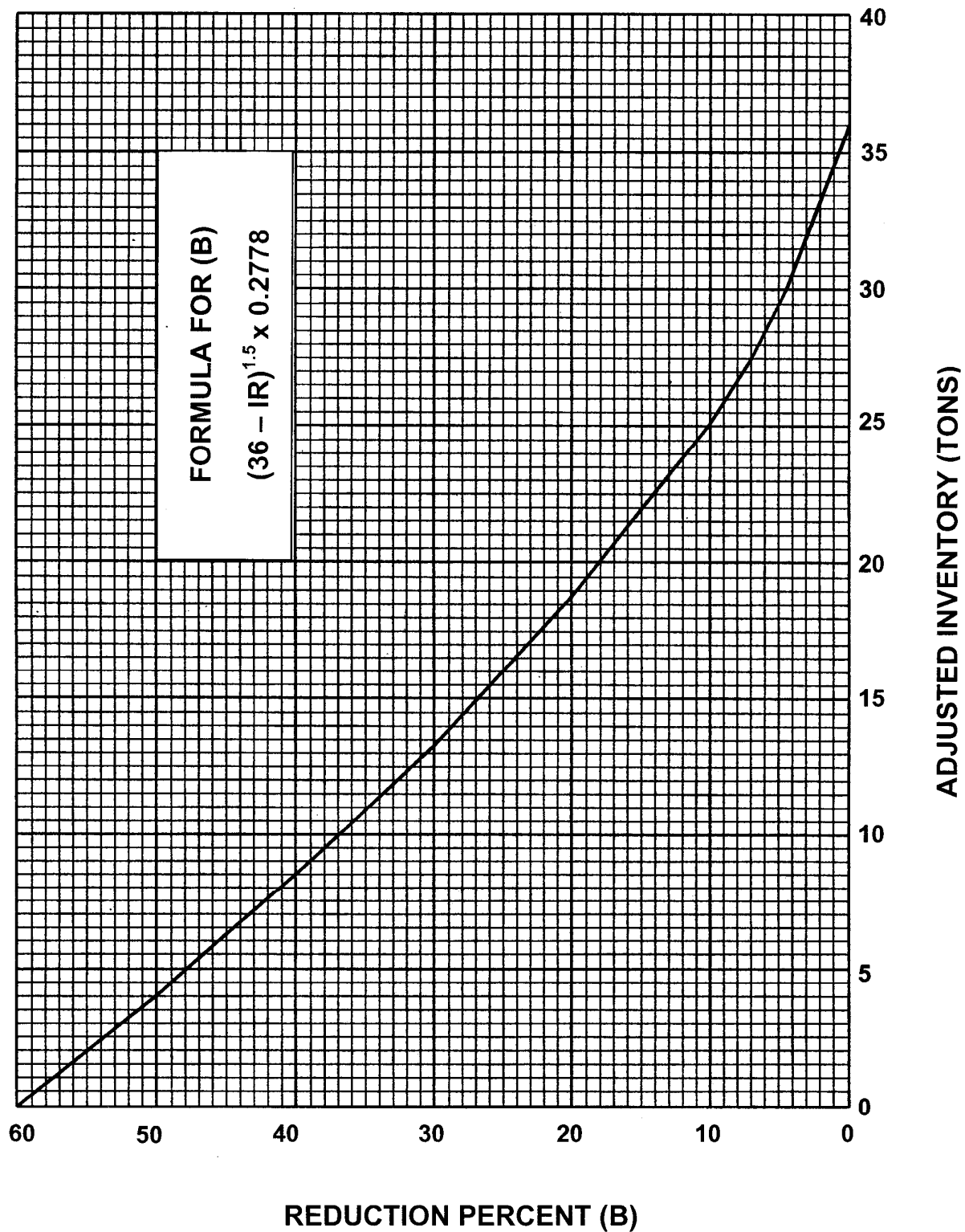S_1 shall not be less than 0% nor greater than 55%.

The chart has:
- Vertical axis (right side): ADJUSTED INVENTORY (TONS), ranging from 0 to 40
- Horizontal axis (bottom): REDUCTION PERCENT (B), ranging from 60 to 0

FORMULA FOR (B)

$$(36 - IR)^{1.5} \times 0.2778$$

Figure 2. Reduction for Adjusted Inventory Tons

2.   Serviceability and Functional Obsolescence (30% maximum)

      a.   Rating Reductions (13% maximum)

If #58 (Deck Condition) is	≤ 3	then	A = 5%
	= 4		A = 3%
	= 5		A = 1%
If #67 (Structural Evaluation) is	≤ 3	then	B = 4%
	= 4		B = 2%
	= 5		B = 1%
If #68 (Deck Geometry) is	≤ 3	then	C = 4%
	= 4		C = 2%
	= 5		C = 1%
If #69 (Underclearances) is	≤ 3	then	D = 4%
	= 4		D = 2%
	= 5		D = 1%
If #71 (Waterway Adequacy) is	≤ 3	then	E = 4%
	= 4		E = 2%
	= 5		E = 1%
If #72 (Approach Road Alignment) is	≤ 3	then	F = 4%
	= 4		F = 2%
	= 5		F = 1%

J = (A + B + C + D + E + F)

J shall not be less than 0% nor greater than 13%.

      b.   Width of Roadway Insufficiency (15% maximum)

Use the sections that apply:

      (1)   applies to all bridges;
      (2)   applies to 1-lane bridges only;
      (3)   applies to 2 or more lane bridges;
      (4)   applies to all <u>except</u> 1-lane bridges.

Also determine X and Y:

X (ADT/Lane) = #29 (ADT) ÷ first 2 digits of #28 (Lanes)

Y (Width/Lane) = #51 (Bridge Rdwy. Width) ÷ first 2 digits of #28

(1)   Use when the last 2 digits of #43 (Structure Type) are not equal to 19 (Culvert):

If (#51 + 2 Ft.) < #32 (Approach Roadway Width) $G = 5\%$

(2)   For 1-lane bridges only, use Figure 3 or the following:

If the first 2 digits of #28 (Lanes) are equal to 01 and

$$Y < 14 \quad\quad \text{then} \quad H = 15\%$$
$$Y \geq 14 < 18 \quad\quad\quad\quad H = 15 \left(\frac{18\text{-}Y}{4}\right)\%$$
$$Y \geq 18 \quad\quad\quad\quad H = 0\%$$

(3)   For 2 or more lane bridges. If these limits apply, do not continue on to (4) as no lane width reductions are allowed.

If the first 2 digits of #28 = 02 and $Y \geq 16$, $H = 0\%$
If the first 2 digits of #28 = 03 and $Y \geq 15$, $H = 0\%$
If the first 2 digits of #28 = 04 and $Y \geq 14$, $H = 0\%$
If the first 2 digits of #28 $\geq$ 05 and $Y \geq 12$, $H = 0\%$

(4)   For all <u>except</u> 1-lane bridges, use Figure 3 or the following:

$$\text{If } Y < 9 \text{ and } X > 50 \quad \text{then} \quad H = 15\%$$
$$Y < 9 \text{ and } X \leq 50 \quad\quad\quad H = 7.5\%$$
$$Y \geq 9 \text{ and } X \leq 50 \quad\quad\quad H = 0\%$$

If X > 50 but $\leq$ 125 and

$$Y < 10 \quad\quad \text{then} \quad H = 15\%$$
$$Y \geq 10 < 13 \quad\quad\quad\quad H = 15 \left(\frac{13\text{-}Y}{3}\right)\%$$
$$Y \geq 13 \quad\quad\quad\quad H = 0\%$$

If X > 125 but $\leq$ 375 and

$$Y < 11 \quad\quad \text{then} \quad H = 15\%$$
$$Y \geq 11 < 14 \quad\quad\quad\quad H = 15 \left(\frac{14\text{-}Y}{3}\right)\%$$
$$Y \geq 14 \quad\quad\quad\quad H = 0\%$$
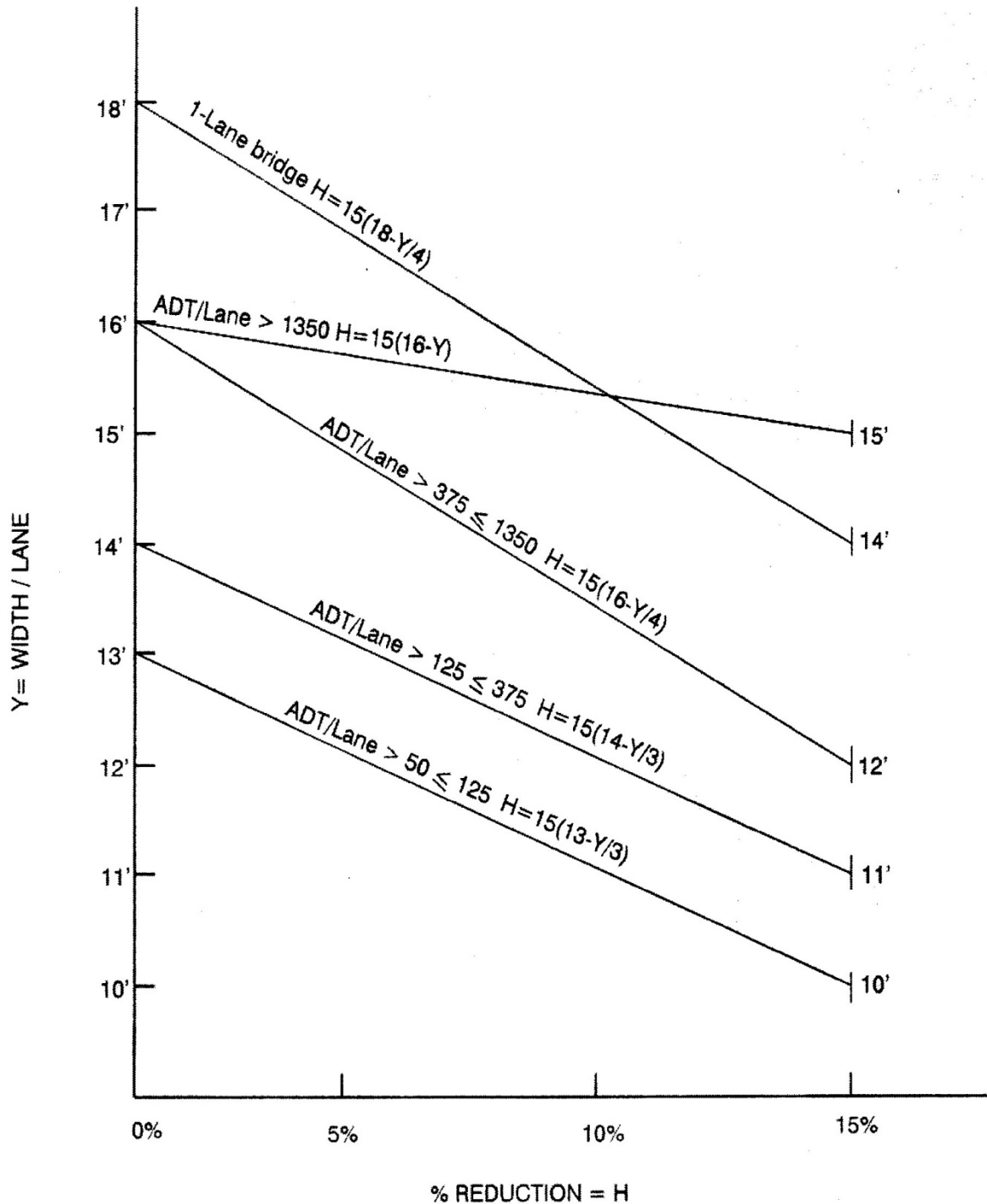
Figure 3. Width of Roadway Sufficiency

If $X > 375$ but ≤ 1350 and

$Y < 12$	then	$H = 15\%$
$Y \geq 12 < 16$		$H = 15 \left(\dfrac{16\text{-}Y}{4} \right) \%$
$Y \geq 16$		$H = 0\%$

If $X > 1350$ and

$Y < 15$	then	$H = 15\%$
$Y \geq 15 < 16$		$H = 15 (16\text{–}Y) \%$
$Y \geq 16$		$H = 0\%$

$G + H$ shall not be less than 0% nor greater than 15%.

c.   Vertical Clearance Insufficiency – (2% maximum)

If #100 (STRAHNET Highway Designation) > 0 and

#53 (VC over Deck) ≥ 1600	then	$I = 0\%$
#53 < 1600		$I = 2\%$

If #100 = 0 and

#53 ≥ 1400	then	$I = 0\%$
#53 < 1400		$I = 2\%$

$S_2 = 30 – [J + (G + H) + I]$

S_2 shall not be less than 0% nor greater than 30%.

3.   Essentiality for Public Use (15% maximum)

     a.   Determine:

$$K = \frac{S_1 + S_2}{85}$$

     b.   Calculate

$$A = \frac{\#29 \ (ADT) \ x \ \#19 \ (Detour \ Length) \ x \ 15}{200{,}000 \ x \ K}$$

             "A" shall not be less than 0% nor greater than 15%.

     c.   STRAHNET Highway Designation:

                     If #100 is > 0   then $B = 2\%$
                     If #100 = 0   then $B = 0\%$

$S_3 = 15 - (A + B)$

S_3 shall not be less than 0% nor greater than 15%.

4.   Special Reductions (Use only when $S_1 + S_2 + S_3 \geq 50$)

     a.   Detour Length Reduction, use Figure 4 or the following:

$$A = (\#19)^4 \ x \ (5.205 \ x \ 10^{-8})$$

             "A" shall not be less than 0% nor greater than 5%.

     b.   If the 2nd and 3rd digits of #43 (Structure Type, Main) are equal to 10, 12, 13, 14, 15, 16, or 17; then $B = 5\%$

     c.   If 2 digits of #36 (Traffic Safety Features)   = 0 $C = 1\%$
                  If 3 digits of #36   = 0 $C = 2\%$
                  If 4 digits of #36   = 0 $C = 3\%$

$S_4 = A + B + C$

S_4 shall not be less than 0% nor greater than 13%.

Sufficiency Rating = $S_1 + S_2 + S_3 - S_4$

The Rating shall not be less than 0% nor greater than 100%.

Reduction

$$y = mx^4$$
$$m = 5.205 \times 10^{-8}$$

$$y = \text{Reduction}$$
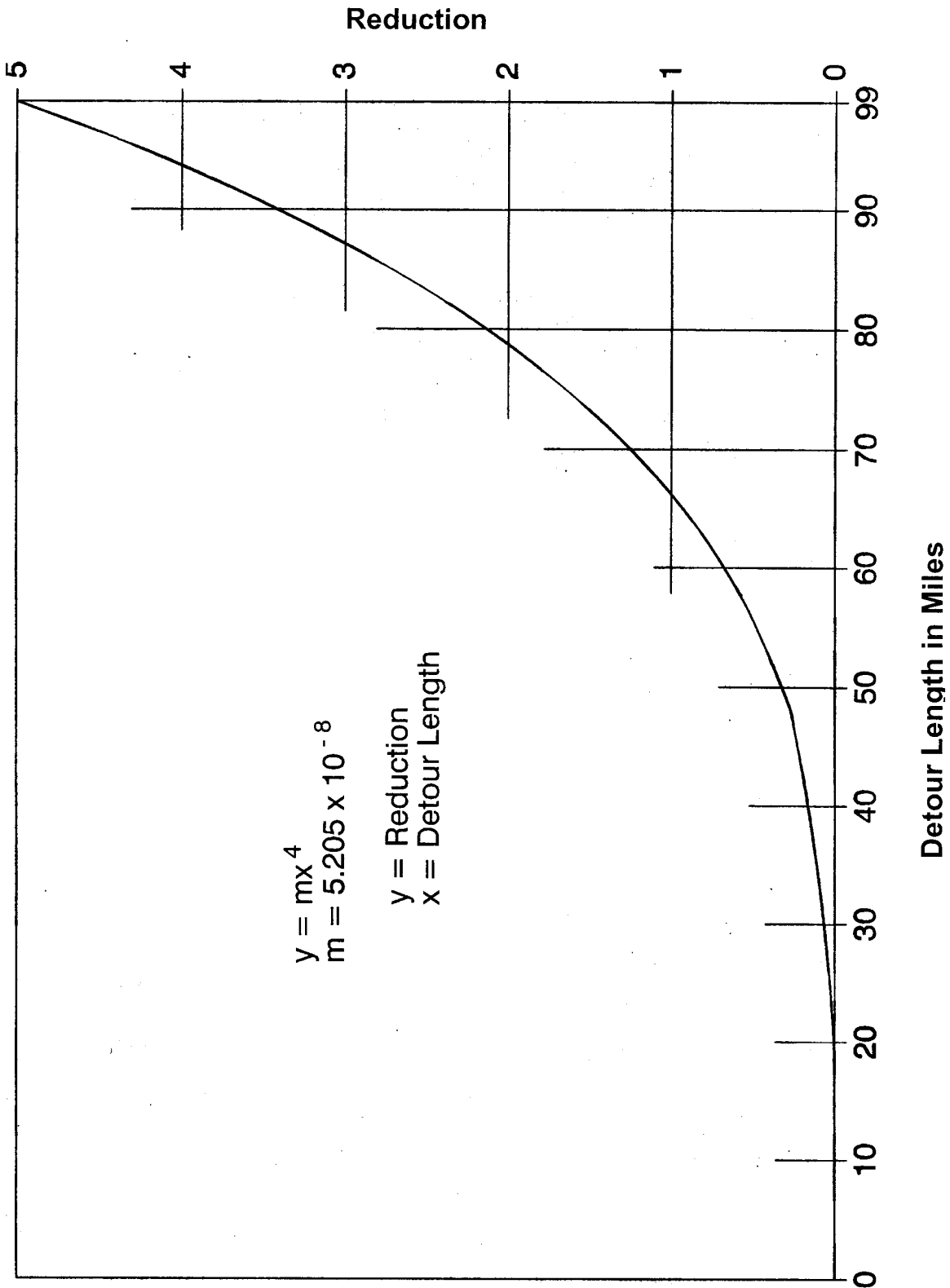$$x = \text{Detour Length}$$

Detour Length in Miles

Figure 4. Special Reduction for Detour Length

Example
Calculation of Sufficiency Rating

1. Structural Adequacy and Safety

    A, B, C, E, F, G, H = Not Applicable
    D = 10%
    $I = [36 - (1.00 \times 22)]^{1.5} \times 0.2778 = 14.6$
    $S_1 = 55 - (10 + 14.6) = 30.4$

2. Serviceability and Functional Obsolescence

    A = 3%, B = 1%, C = 4%, D = NA, E = NA, F = NA
    $J = (3 + 1 + 4) = 8\%$
    $X = \dfrac{18500}{2} = 9250 \qquad Y = \dfrac{26.0}{2} = 13.0$

    (1) If $(26.0 + 2) < 40$ then   G = 5
    (2) Not Applicable
    (3) Not Applicable
    (4) If X = 9250 and Y = 13.0   then   H = 15

    $G + H = 5 + 15 = 20$ (however, maximum allowable = 15)
    $I = 0$
    $S_2 = 30 - [8 + (15) + 0] = 7.0$

3. Essentiality for Public Use

    $K = \dfrac{30.4 + 7.0}{85} = 0.44$

    $A = \dfrac{18500 \times 8}{200{,}000 \times 0.44} \times 15 = 25.2$ (however, maximum allowable = 15)

    $B = 0$
    $S_3 = 15 - (15 + 0) = 0$

4. Special Reductions

    $S_1 + S_2 + S_3 = (30.4 + 7.0 + 0.0) = 37.4 < 50$
    $S_4 = NA$

SUFFICIENCY RATING = 30.4 + 7.0 + 0.0 = 37.4

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